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Revue canadienne d'audition

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Special Issue: Here Comes the "Noise"!

Estimating Noise Exposure Under Headsets

CSA Z107.56-13: Measurements of Noise Exposure

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Alberto Behar is a name that you should all know. Other than being a really nice guy, Alberto has been a regular columnist with the *Canadian Hearing Report* about virtually all things related to noise and noise control. He has written a previous column about the difference between the terms, sound level and intensity, which to this day, seems to be one of the most requested articles for permission to be reprinted. Alberto is a retired engineer, where the word "retired" is a misnomer. He is associated with Ryerson University and can be found each day in their "Smart Lab" hard at work on a computer. He knows five languages and was a recipient of a Fulbright Scholarship. In short, he is a very smart fellow.

And Alberto has graciously agreed to be the guest editor of a part of this issue – no surprises, but the topic is about noise and noise control. Under his purview, we have articles about a new Canadian proposed standard (CSA Z107.56-13) about the measurement of noise exposure. Standards should have more exciting names than CSA Z107.56-13, but the content is interesting regardless of its name. Alberto has also written a most delightful article with the exciting name "dB, dBA, SPL, HL, Leq, Lx, What Else?", and it's about dB and its various guises.

Tim Kelsall, another gentleman whose name ranks among the highest levels of respect in the field of noise and its control, has written a very practical article called "Estimating Noise Exposure Under Headsets," and …, it's about estimating noise exposure under headsets.

In conjunction with some faculty at Western University (the former University of Western Ontario), some of the graduating students have assessed the accuracy of Smartphone Sound Level Meter apps that are currently on the market- they looked at…., well, just read their article.

Brian Allman may need some introduction since he is new to the Canadian scene despite being Canadian. I met Brian at the conference in Buffalo, NY, celebrating Don Henderson's retirement and life's work (*Canadian Hearing Report* 8-1). After obtaining his PhD at SUNY-Buffalo, we now have him back in Canada at Western University. He has written this issue's Spotlight on Science. His subject area is uncovering the neural basis of tinnitus using laboratory animal models. Welcome back to Canada.

I hope you enjoy this issue. We certainly enjoyed working on it.

Marshall Chasin, AuD, M.Sc., Aud(C), Reg. CASLPO, Editor-in-Chief
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Canadian Hearing Report 2013;8(6):3.

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PEOPLE FIRST

Alberto Behar est un nom que vous devriez tous connaitre. En plus d'être un gars vraiment gentil, Alberto est un chroniqueur régulier de la *Revue canadienne d'audition* sur virtuellement tous ce qui se rapporte au bruit et au contrôle du bruit. Il a déjà rédigé une chronique au sujet de la différence entre les termes, niveau de son et intensité, qui jusqu'à date semble être un des articles pour lequel on demande le plus de permission de réimpression. Alberto est un ingénieur à la retraite, toutefois, le mot "retraite" est une fausse appellation dans son cas. Il est associé à l'université Ryerson et on peut le trouver chaque jour dans leur "Smart Lab" travaillant fort sur un ordinateur. Il parle cinq langues et est récipiendaire d'une bourse de Fulbright. Bref, c'est un collègue très intelligent.

Alberto a gracieusement consenti à être le rédacteur invité d'une partie de ce numéro– sans surprise, le sujet est le bruit et le contrôle du bruit. Dans ce cadre, nous avons des articles au sujet des nouvelles normes canadiennes proposées (CSA Z107.56-13) au sujet des mesures de l'exposition au bruit. Les normes devraient avoir des noms plus attrayants que CSA Z107.56-13, mais le contenu est intéressant peu importe le nom. Alberto a aussi écrit un article des plus enchanteurs avec le plus attrayant des titres "dB, dBA, SPL, HL, Leq, Lx, Quoi d'autre?", et c'est au sujet du dB et de ses signes variés.

Tim Kelsall, un autre monsieur dont le nom se classe parmi les plus respectés dans le domaine du bruit et de son contrôle, a rédigé un article très pratique sous le titre "Estimation de l'exposition au bruit à travers des écouteurs," et …, c'est au sujet de l'estimation de l'exposition au bruit à travers des écouteurs.

En conjonction avec le personnel enseignant de Western University (Jadis the University of Western Ontario), quelques un des étudiants de dernière année ont évalué l'exactitude des applications des sonomètres des téléphones intelligents qui sont actuellement disponibles sur le marché- ils ont étudié …, bon, juste lisez leur article.

Brian Allman a besoin d'une petite présentation étant donné qu'il est nouveau dans la scène canadienne même s'il est Canadien. J'ai rencontré Brian à la conférence à Buffalo, NY, célébrant le départ à la retraite de Don Henderson et son œuvre de toute une vie (*Revue canadienne d'audition* 8-1). Après son doctorat du SUNY- Buffalo, nous l'avons de retour au Canada à Western University. Il a rédigé la rubrique Spotlight on Science de ce numéro. Son sujet est " Mise à jour de la base neurophysiologique du tinnitus en utilisant des modèles d'animaux de laboratoires. Bon retour au Canada.

J'espère que vous prendrez plaisir à lire ce numéro. Nous avons certainement pris du plaisir à travailler dessus.

Meilleures salutations,

Marshall Chasin, AuD, M.Sc., Aud(C), Reg. CASLPO
Rédacteur en chef
marshall.chasin@rogers.com

Canadian Hearing Report 2013;8(6):7.

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Music Is What I Do. Noise Is What My Neighbor Does. Awful Noise Is What My Kids Listen To!

My good friend Marshall Chasin asked me to write an editorial related to noise.* It is very difficult to say "no" in general and even worst to do it to a friend. So, here we go …

The Cartesians (students of the French philosopher Descartes**), used to start philosophical discussions with their opponents, by defining the terms that were to be used. They will say, for instance, "philosophy is…" and, of course, their opponents will have a completely different definition of the same. As a result, they will spend half of their time discussing their definitions, resulting in such an irrational use of their time…

**Here we are dealing exclusively with acoustical noise, that has nothing in common with non-acoustical noises such as the visual, thermal, cellular, etc.*
***Also known as Renatus Cartesius (1596–1650).*

I am anything but a philosopher, but the idea of using proper wording is something dear to my heart , so, why not to start by defining "noise." The "definition" at the beginning of the article is obviously related to the psychological effect from noise, related basically to the subjective effect on the listener. It can be translated as "an undesirable sound" for short.

There is no doubt about it, a physical definition that reads as: "a sound, generally random in nature, the spectrum of which does not exhibit clearly defined frequency components".

In this issue of the *Canadian Hearing Report* you will see several articles related to noise. Of note is one written by my distinguished colleague and friend, Tim Kelsall, who is the head of the Noise and Vibration Section of Hatch Associated. On top of teaching courses and making presentations on related subjects, he is the chair of the CSA Occupational Hearing Conservation Technical Committee actively involved in the writing of several noise standards. Another article is more in line with the issue of definitions and deals with several terms that are very often used but not so often understood.

Now, after reading this editorial and knowing what exactly noise is I hope you will enjoy even more reading those articles and the rest of the articles in this issue.

Alberto Behar, P.Eng., C.I.H.

Canadian Hearing Report 2013;8(6):9.

La musique est ce que je fais. Le bruit, c'est mon voisin. Le plus horrible des bruits, c'est ce que mes enfants écoutent!

Mon bon ami Marshall Chasin m'a demandé d'écrire un éditorial au sujet du bruit. * c'est dur de dire "non" en général et encore plus dur de le dire à un ami. Alors, on y va…

Les Cartésiens (Les étudiants du philosophe Français Descartes**), avaient l'habitude de commencer des discussions philosophiques avec leurs adversaires, en définissant les termes qui seront utilisés. Ils diront par exemple, "La philosophie est …" et, bien entendu, leurs adversaires auraient une définition complètement différente. Ils vont passer la moitié de leur temps à débattre leurs définitions, résultat, une telle utilisation irrationnelle de leur temps.

Je n'ai rien d'un philosophe, mais l'idée d'utiliser la formulation adéquate est très chère à mon cœur, alors, pourquoi ne pas commencer par définir "bruit." La "définition" au début de l'article est évidement liée à l'effet psychologique du bruit, lié essentiellement à l'effet subjectif sur l'auditeur. Il peut être traduit comme "un son indésirable" pour faire court.

Il n'y a aucun doute, une définition physique qui se lit comme suit: "un son, généralement aléatoire en nature, dont le spectre n'exhibe pas des composants de la fréquence clairement définis".

Dans ce numéro de la *Revue canadienne d'audition*, vous allez trouver plusieurs articles au sujet du bruit. A noter, un article rédigé par mon ami et collègue distingué, Tim Kelsall, qui est le chef de la section Bruit et Vibration de Hatch Associated. En plus d'enseigner et de présenter en tant que conférencier, il est le président du comité technique de la protection professionnelle de l'ouïe de la CSA, comité impliqué activement dans la rédaction de plusieurs normes sur le bruit. Un autre article est plus en ligne avec l'enjeu des définitions et touche à plusieurs termes qui sont très souvent utilisés mais pas assez souvent compris.

Maintenant, après avoir lu cet éditorial et compris ce qu'est le bruit exactement, j'espère que vous allez prendre plus plaisir à lire ces articles et le reste des articles dans ce numéro.

Alberto Behar, P.Eng., C.I.H.

Canadian Hearing Report 2013;8(6):10.

**Ici, on traite exclusivement le bruit acoustique, qui n'a rien en commun avec les bruits non acoustiques tel le visuel, thermal, cellulaire, etc.*
***Aussi connu sous le terme Renatus Cartesius (1596–1650).*

By Calvin Staples, MSc
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Hearing aids are the bread and butter of audiology today. I like hearing aids. I like how they work, the cool accessories we can now access, and the benefit they can provide so many people with treatable hearing loss. However, I am constantly reading, listening, and urging audiologist and other hearing health care professionals to be more than the device we are selling; a common theme at the past CAA conference. Aural rehab, vestibular, auditory processing, and (this is for you Marshall) music, the usual suspects are some of the other expertise audiologists posses but are often irregularly used. I believe audiology needs to expand beyond hearing aid sales and service and begin to work collaboratively with interest groups to expand our knowledge and community support. As I said, I like hearing aids, but I like many other areas of this profession as well and I think the work CAA has done to help grow our scope of practice and professional support should be applauded. The scientific program at the 2013 CAA conference may have been our best yet! The following blogs are a bit of an audiology potpourri.

WE MUST RETURN TO OUR REHABILITATIVE ROOTS: PART I MAURICE H. MILLER PHD

By Kevin Liebe

Author's Note: My profound appreciation to James Jerger, Audiology's most prolific scientific contributor and intellectual leader of the profession. His comments, suggestions, corrections made this article what it is and I am most appreciative of his working with me on its final preparation.
By Maurice H. Miller, Ph.D.

I write this article from a serious and profound concern for the future of audiology as I have known it and served it for well over half a century. A major problem exists: audiologists have concentrated so much on the "testing" and "fitting" aspects of hearing aids that many of our practitioners feel less comfortable than speech/language pathologists in performing long-term rehabilitative services; this despite the inclusion of auditory rehabilitation under various designations in course work and practica at so many of our universities.

The present state of performed (or not performed) audiologic rehabilitation services by audiologists is alarming! ASHA's 2012 survey of 2,000 ASHA-Certified Audiologists from a variety of work settings found that only 17% provide "auditory training" and 4% provided speech reading/lip reading. There is much current focus on the instrument and so little on the rehabilitation of the user.

Let me stress at the outset that this discussion focuses only on adults, primarily the "elderly." Children are often served by a "team" that includes audiologist, speech/language pathologists, otolaryngologists, pediatricians, social workers, psychologists and others which, at its best, provides diagnostic findings and makes joint recommendations for the diagnosis, therapy and other indicated interventions.

LOOMING PROBLEMS

Some practicing audiologists (many of whom I have trained) tell me that the difference in hearing aid prices between Costco and similar operations is that the hearing-impaired patient is welcomed by the audiologist to revisit after the trial period as many times as he wishes at no additional cost. But this is a totally ineffective way of providing the audiologic rehabilitation that these patients, especially the elderly, and especially those with associated cognitive problems, desperately require.

I fear that unless we provide the audiologic rehabilitative services and associated services (counseling–often long-term, situationally determined use of amplification) on an organized, scheduled, initially in-person basis, our future and that of those we serve is in deep jeopardy. Increasingly the technology for hearing testing and hearing aid fitting can be performed equally well by the audiologist or the dispenser, or by a technician or even by appropriate technology. And we are left with a huge increasingly elderly population whose auditory problems are both peripheral and central.

Amplification can benefit those with peripheral auditory impairments to varying degrees, but less so in the case of central processing disorders, unless it is accompanied by necessary individualized rehabilitation services. Moreover, charging 3–4 times more than some massive distributor services and telling the patient after the hearing aid(s) is sold to come in if you have a problem is not an appropriate or defensible recommendation.

MUCH HAS CHANGED IN AUDIOLOGY SINCE WWII

In the World War II era, we could require a comprehensive total rehabilitation program. But our present primarily elderly population is not subject to the same controls that military audiologists could exert over their patients. In the absence of insurance coverage, and with an orientation that after paying many thousands of dollars for hearing aids they should resolve all hearing problems, we are left with many expensive, fully digital, carefully programmed hearing aids in the proverbial dresser drawers of this generation.

HOW DID THIS SITUATION EVOLVE?

The rapid evolution of audiology as an independent and sustaining specialty occurred during and after World War II.* The object was to rehabilitate individuals who had sustained service-connected hearing loss. In this role, in addition to diagnostic services, audiologist then provided a host of rehabilitative services, including hearing aid selection and use, speech (lip) reading and auditory training (often in group classes), patient counseling and support in understanding and adjusting to the hearing loss. In providing these services, we were acting as case managers rather than technicians or diagnosticians. Mark Ross has correctly stated that regardless of how well we administer and interpret sophisticated diagnostic procedures, we basically remain technical support persons for the medical profession.

It is when we are the profession responsible for evaluating and managing the communication disorder and handicap imposed by a hearing loss that we fully come into our own as independent professionals.

The practice and progression of audiologic rehabilitation, Ross states, was not comparable to the growth of the medical/ diagnostic role when the field moved into academia and into the world at large after World War II. Instead of audiologic rehabilitation being a core and defining activity, it has moved into the distant periphery of the profession. In many academic programs it has been relegated to one or two courses in speech reading and auditory training and often assigned to the lowest ranking professionals in the department. For example, speech reading and auditory training are often taught by master's level audiologists while the doctoral level professors teach primarily in the diagnostic area. We still pay lip service to audiologic rehabilitation and claim it philosophically as our own, but we in academia "just don't do it."

THE REIMBURSEMENT ISSUE

There are ongoing and much needed efforts to reimburse audiologists for "aural and vestibular rehabilitation" in addition to diagnostic services under Medicare. If enacted, the proposed Medicare Services Auditory Enhancement Act (HR-2300) will, hopefully, provide the necessary impetus to move audiologists into the rehabilitation arena that our patients so desperately require and that we alone can provide if willing and trained to do so.

SCOPE OF THE PROBLEM

Data on the prevalence of hearing loss in adults are striking. According to the World Health Organization, over 360 million people, or about 5% of the world's population have some degree of disabling hearing loss. In the United States, the figure often quoted is 28 million, although this is probably a significant under-estimate. Yet the number of persons who receive competent rehabilitative care remains disappointingly low. In part this is because most adult hearing loss occurs gradually, without pain or noticeable discomfort, making it a condition easy to deny and to delay care.

Please go to Kevin Leibe's blog to read part II.

http://hearinghealthmatters.org/hearingviews/2013/must-return-rehabilitative-roots/

RAY DOLBY PASSES AWAY

By Marshall Chasin

On Friday Sept 13, 2013, Ray Dolby passed away. With the passing of Dr. Bose several months ago, the year 2013 was not among the best for the audio industry.

I met Ray Dolby at an Audio Engineering Conference (AES) in Los Angeles about 20 years ago and it was my least-cool life moment.

After being introduced, I proceeded to explain to him exactly how his system worked with such vigor and excitement that people gradually started to move away from us. Fortunately for me, Ray was trapped in a corner and could not withdraw any further. This was perfect; I had time to explain in detail every aspect of his system. I don't know if Ray Dolby had "groupies" but I was one of his more ferocious, at least on that day.

For years, in a 3rd year course, I had taught (and still do) how the Dolby system reduced tape hiss and improved the signal to noise ratio (SNR) in the higher frequency region in acoustic phonetics at the University of Toronto. Meeting Ray Dolby was like meeting Gunnar Fant or Peter Ladefoged – both giants in the field of acoustics and speech production.

For those who really know me, as a Canadian, I tend to be understated. I have made ear monitors for the Stones, U2, Rod Stewart, and I even see Elvis Presley from time to time in my Musicians' Clinic. I never lose my cool with these folks, but Ray Dolby was a notch above Blue Suede Shoes.

Now that I have you hooked, here is how the Dolby system worked.

1. Tape media have a noise floor that is frequency independent. The noise level is as high for the lower frequencies as it is for the more treble notes.
2. When speech or music is recorded onto a tape, since most of the energy is in the lower frequency region, there is a good SNR for the lower frequencies, but alas a poorer one for the higher frequency region. Because of this, the higher frequency tape noise is audible – the sibilants are not sufficient to block it out. That is, despite the tape noise being the same for all frequency regions, it is only audible in the higher frequency ranges.
3. Now here is Ray Dolby's genius – knowing that there would be a poor high frequency SNR, Mr. Dolby pre-emphasized the higher frequency region of the music or speech BEFORE placing it on the tape. This was his real genius!
4. The pre-emphasized music or speech was then recorded onto the tape but now with a much better SNR.
5. Before the playback, this pre-emphasized high frequency speech or music was undone (i.e., a slight high cut filter). This brought back the speech or music spectrum to the initial state but the noise floor in the higher frequency region (being filtered out) was now inaudible.
6. The result is that the initial spectrum was identical to the final spectrum so it was ideal for music and for speech analysis. One could make a recording onto tape with Dolby and would not alter the elements of the speech at all – just get rid of some audible his.

I have had some phonetics professors over the years who have sworn by the hiss. When eliciting speech samples from various languages they always felt more at home, and more comfortable, doing a transcription task if there was that constant background hiss. But, other than these rogue phonetic professors, Dolby noise reduction had no downside.

As the recording media became more advanced – CD, MP3 files, and .wav files – this initial innovation was no longer necessary. It was a direct response to the inherent noise floor found on tapes. Yet Dolby as a company continued to innovate.

After more than 20 years I am sure that Mr. Dolby's colleagues forgot about that incident and I am sure that the restraining order against me will have been forgotten as well…

http://hearinghealthmatters.org/hearthemusic/2013/ray-dolby-passed-away-late-last-week/

BPPV ANALOGIES

By Alan Desmond

ENTER THE SANDMAN

Last week, I told a story about my difficulty in getting a patient to understand the role of meclizine in the treatment of benign paroxysmal positional vertigo (BPPV). It got me thinking about some of the analogies we use to describe certain concepts about BPPV that may be more relatable to a patient than trying to help them understand things like "free floating otoconia."

When describing posterior canal BPPV and canalith repositioning (CRP), I often use the analogy of a hula hoop (the posterior canal) with some sand (the loose otoconia) inside, only this hula hoop has a plug somewhere (the cupula). I describe CRP as rotating the hula hoop, using gravity to move the sand away from the plug, towards the opening in the hula hoop (the opening to the vestibule) where the sand somehow got in. If I can get the sand to the opening, the sand will come out and the BPPV will be gone.

Particularly when discussing horizontal canal BPPV, I explain that the sand in the hula hoop may not move very much when it is moved side to side (like shaking the head "NO"). But when you tilt the hula hoop vertically on its side (as when you are supine) gravity is introduced into the equation and the sand shifts every time you roll your head side to side.

LET IT SNOW, LET IT SNOW, LET IT SNOW

Another analogy we use frequently is the snow globe. Several concepts regarding BPPV can be explained with this example. When explaining why people get BPPV, we describe otoconia debris (now as snowflakes instead of sand) coming loose from the utricle. If the globe is upright, the snow will settle on the little village, or Santa's feet, or whatever. If you lay the snow globe on its side, the snow won't settle on the village, but will go wherever gravity takes it. In other words, if the otoconia debris comes loose and settles while the person is upright, it will settle in the vestibule, only to be asymptomatically absorbed. But if the otoconia debris comes loose, and the patient lies down, the debris may find its way into a semicircular canal. We also use this to describe fatigue. If you keep shaking the snow globe, it will keep snowing and the debris won't settle anywhere.

http://hearinghealthmatters.org/dizzinessdepot/2013/bppv-analogies/

WHAT ARE THE TELLTALE SIGNS THAT YOU MIGHT BE AN AUDIOLOGIST

By David Kirkwood

- When you tell people what you do for a living, do they often say, "What?"– and expect you to laugh.
- When you're standing behind an elderly person in the supermarket checkout line, do you have to resist a powerful urge to push his earmold properly into his ear?
- You find battery stickers on the bottom of your shoes and in your hair.

If you answered yes to any of these, then, just possibly, you might be an audiologist.

So says the hearing aid manufacturer GN ReSound in a tongue-in-cheek post that it published recently on its blog, In Your Ear (http://gnresoundblog.com/2013/09/18/you-might-be-an-audiologist-if/).

In a variation on the comedian Jeff Foxworthy's classic "You might be a redneck" routine, ReSound suggests some humorous ways to complete the sentence "You might be an audiologist if…" Among these are:

- …you give your card to the guy in the car next to you with his speakers blasting and tell him to call you in a few years.
- …you're not grossed out by cerumen.
- …you find yourself talking loudly for no reason.

ReSound also invited its Facebook friends to come up with some of their own telltale signs that reveal if a person is an audiologist. Their suggestions include:

- …you cringe when someone mentions using Q-tips in their ears.
- …you have a random copy of hearing aid software in the trunk of your car.
- …you bust out your sound level meter app ... in church.

http://hearinghealthmatters.org/hearingnewswatch/2013/can-tell-might-audiologist/

WHAT DOES 4000 HZ TELL YOU?

By Jane Madell

We all know hearing aids make things louder. But does it matter exactly how much louder and whether it makes it louder throughout the frequency spectrum? Everyone will say yes, it does. But how often do we check that hearing aids (or cochlear implants) are doing what we hope they are doing? Is it okay to hear well through 2000 Hz and not hear high frequencies at the level of speech? How about hearing to 1000 Hz and not well above 1000 Hz? How about hearing well only through 500 Hz? If we set hearing aids using real ear technology, do we know if the child is hearing at every frequency?

WHAT SPEECH INFORMATION IS AVAILABLE WHERE?

Different speech information is available at different frequencies. When I was a relatively young audiologist, I worked at the New York League for the Hard of Hearing. Dorothy Noto Lewis was the director. She taught us that we needed to be able to predict a child's hearing levels by listening to the child speak. We tried to anticipate the degree of hearing loss before testing and draw the audiogram based on talking to the child and observing response to sound. It was terrifying when I started doing this but it was a WONDERFUL learning experience. It made it very clear to me that I needed to know what a child heard and that I needed to fix what they did not hear.

LOW FREQUENCIES

250 Hz provides voicing cues and the first formant of /n/,/m/ and /ng?. So if a child is having problems getting voicing cues we should check if they have enough information at 250 Hz. 500 Hz provides information for manner of production, first formant for most vowels, noise bursts for plosives, and information for semi-vowels and laterals /l/ and /r/.

If a child is having problems confusing

manner of consonants, we should look to where the child is hearing at 500 Hz.

MID FREQUENCIES

1000 Hz provides additional cues of manner, nasal consonants, back and central vowels, noise bursts of most plosives and semi-vowels. 2000 Hz provides cues for place of consonant and additional information about manner, front vowels, noise bursts of most plosives and affricates and turbulent noises of fricatives /sh/, /f/, and /th/. So if a child is having problems hearing fricatives, we need to check how they hear at 2000 Hz.

HIGH FREQUENCIES

4000 Hz provides more information on consonant production, third formant for vowels, noise bursts for plosives and affricates, turbulent noise of voiced and unvoiced fricatives. 6000 Hz provides information required for perception of /s/, and 8000 Hz provides information on turbulent noise of all fricatives and affricates. Let's remember that you need /s/ to learn prepositions, possessives, etc. It is a critical frequency to hear.

USING THIS INFORMATION

For the most part, the speech acoustics courses we took were viewed as theory. Unless you were involved in research, most audiologists do not think of this information as clinically useful. In fact, it is so very, very critical. Dan Ling used to say *"What they hear is what they say."* Dorothy Noto Lewis would definitely have agreed with that. We can check that a child is hearing throughout the frequency range by getting aided thresholds and we can also listen to what the child says. It is not unusual to have audiologists and teachers, etc., say that the child is not saying /s/ or some other phoneme because he has a hearing loss or an articulation problem. But maybe he is not saying it because he cannot hear it!

LISTEN TO THE KIDS

If a therapist says that a child cannot hear /s/ don't wait for the child to outgrow it. Check that the child is hearing high frequencies. If not, fix it. If it turns out he does have thresholds in the high frequencies, then we know something else is causing this, and the therapists know they need to fix it. DO NOT ASSUME. Test and find out what is real. I can tell you one thing for certain: if a child does not hear high frequencies, he will not be able to use that information for language learning.

http://hearinghealthmatters.org/hearingandkids/2013/4000-hz-tell/

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How to Tell Your Mother (She Has Hearing Loss)

By Gael Hannan
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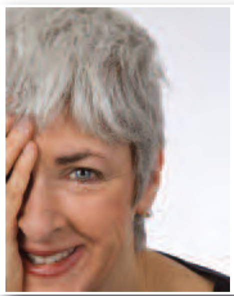

Hi, Mom, how're you doing?

Fine, darling! This is a treat – are you staying for dinner?

No, I just dropped in for a coffee chat.

You usually phone, but this is nicer, face to face.

Well, that's what I wanted to talk…

Sorry, dear, I didn't catch that?

…Mom, I didn't call you, because talking on the phone is tough these days. Do you think it's time to get your hearing checked?

Oh, not that again! Darling, I did – and she said my hearing was normal for my age. Everyone has difficulty hearing past the age of 60.

Yeah, but Mom, you're over 70 –and that checkup was two years ago!
You know, you're not as nice as your sister. She doesn't stick pins in me like this.

Mom, these are facts, not criticism. And you're forgetting the part where the audiologist said it's also normal to DO something about hearing loss.

You want me to spend thousands of dollars – that I don't have – for hearing aids – which I really don't need?

Mom, she said you DO need them!

All they want is to sell you a hearing aid. And besides, my hearing doesn't bother your father.

Really, have you asked him? Mom, we all hate seeing you miss out on things. You tune out at family gatherings – which you always host, to make sure you're too busy to sit and chat because you can't hear what people are saying.

Darling, I do NOT have hearing loss. That term is way too dramatic for missing the odd word here and there.

You're always asking us to repeat ourselves! We don't mind, but you have to help yourself. Please, make another appointment. I'll make it – and go with you!

Do you still want that coffee, or are you leaving?

Does any of that sound familiar?
When I first tell someone about my hearing loss, we usually have a short chat. I say I'm hard of hearing and could they speak up or face me. They say *"oh, sorry,"* and I say *"oh, don't be."* Lately, the chat often includes an extra question: *My mother (or whoever) won't admit her hearing loss and it drives our family nuts. How can I convince her to get hearing aids?*

My usual response is a variation on: "Oh geez, I dunno, have you tried this, and hey, good luck with that!

It's not easy to control or guide another person's hearing loss journey. Studies show that it takes years for a person to resolve the Internal Debate – that period stretching from the first suspicion of hearing loss, whether it's a personal thought or one offered up by a family member *(Dad, you're going deaf!)*, to actually doing something about it. The shorter the internal debate, the better – but the person must also accept help willingly, or at least *not* dead-set against it. Anyone dragged kicking, screaming or hog-tied to an audiologist by well-meaning relatives will not be open to professional advice. And it may harden – into cement – their suspicions that the relatives are "out to get me" and that hearing care professionals are evil beings with a financial agenda.

Some families receive advice to stop enabling a loved one's poor communication. In an effort to force their hand to seek help, the family 'should' stop responding to *pardon* or *what*, refuse to speak up, and stop playing the translator in group conversations or on the telephone. I'm not a psychologist, but I share the belief with many other people who have hearing loss that this strategy, no matter how well-intentioned, is liable to be misinterpreted as insensitivity and lack of caring. It ignores the psycho-social issues at the heart of hearing loss, and could push the person further into isolation and frustration. At the very least, it will cause a few rousing arguments and many hurt feelings. The strategy might work with some people, but my blood runs cold at the thought of being subjected to this type of tough love.

My father always encouraged me to be open about my hearing loss, and now the shoe is on the other foot. I'm telling *him* about positive hearing strategies. After years of struggling with TV, he finally turned on the closed captioning – not because of my nagging, but because he wanted to understand his favorite shows. And, after years of resisting hearing aids, he finally got a set, but only because he and his lady friend love to chat and laugh. He adopted both strategies for his *own* reasons and on his *own* timeline. He was *ready*.

According to renowned hearing care researcher and hearing industry analyst Sergei Kochkin, the key reasons for a person's resistance to hearing help include inadequate information, stigma, and lack of trust in hearing aid professionals. The reasons vary from person to person – and so does the success rate of family members who try to force hearing aids on loved one, before they are emotionally ready.

The next time someone asks me how to tell their mother she needs to do something about her hearing loss, I would like to say:

- She already knows.
- Treat her protests and decisions with respect, because your frustration is *nothing* compared to hers.
- Demonstrate that better communication will be good for everyone in the family.
- Let her know you want her to be safe.
- Don't refuse to accommodate her needs – what would that achieve? Even when she gets a hearing aid, you may still have to speak up and repeat yourself.
- Learn as much as you can about her hearing loss and the communication strategies that will help in her daily life. This will also help you manage *your* frustrations.
- Don't give up – be persistent but patient.
- Communicating well is ultimately her choice.

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Uncovering the Neural Basis of Tinnitus: Using Laboratory Animal Models in Tinnitus Research

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Subjective tinnitus is characterized by the perception of a sound which has no acoustic source in the environment. Often, this phantom sensation is described as a "ringing" or "buzzing" in one or both ears. Nearly all adults will experience tinnitus at some point in their life, albeit perhaps only for a short time, and most likely as a consequence of exposure to loud noise. For ~10% of the general population, however, tinnitus is a chronic condition that can lead to disturbance of sleep, difficulty concentrating and, in some cases, severe forms of depression, all of which can negatively affect one's quality of life.

Unfortunately for tinnitus sufferers, a lack of understanding of its neural basis has hindered efforts to devise completely effective treatments. Early theories of tinnitus speculated that its signals originated in the cochlea and propagated to the brain via the auditory nerve; however, this theory has been challenged because tinnitus often persists after the auditory nerve has been surgically transected. Moreover, support for a central generator of tinnitus has emerged from several neuroimaging[1–3] and magnetoencephalography[4–6] studies on tinnitus patients which have found that their brain activity is altered compared to that of non-tinnitus subjects, during both quiet conditions as well as in response to acoustic stimuli. At present, however, it remains difficult to conclude from such non-invasive studies to what extent each of the reported changes is responsible for the onset and persistence of tinnitus.

To help uncover the neural basis of tinnitus, a number of laboratory animal models have been developed over the past ~25 years, with the vast majority using rodents (e.g., rats, mice and hamsters). It is important to note that prior to assessing any changes in brain activity that may underlie tinnitus, it was necessary that researchers first overcome the challenge of developing behavioural tests that were capable of determining whether or not animals were actually experiencing tinnitus. Since Jastreboff and colleagues[7] first established a rat model of tinnitus, a variety of behavioural paradigms have been developed to screen rats and other laboratory animals for noise- and drug-induced tinnitus. In general, the majority of these initial behavioural paradigms involved training an animal to perform a distinct behaviour when sound was presented in its environment, and a different behaviour during quiet conditions. Then, following noise or drug exposure, if the animal mistakenly behaved during quiet conditions as though it was "hearing" an acoustic stimulus, the researchers concluded that the animal was experiencing tinnitus. Based on these behavioural paradigms, it is now well-established that, similar to humans, excessive exposure to loud noise and ototoxic drugs can induce tinnitus in laboratory animals.

Once researchers were able to reliably assess tinnitus-like behaviour in laboratory animals, numerous studies followed in which the animals that had screened positive for tinnitus were then anesthetized and microelectrodes were inserted into various regions of their brains to record how their neural activity was altered compared to non-tinnitus animals. In recent years, there has been a significant increase in the number of studies that have used laboratory animal models to investigate the putative neural mechanisms underlying tinnitus. Despite this increased attention, there is still debate as to whether subcortical or cortical mechanisms are responsible for generating tinnitus. That said, there is mounting support from human studies as well as laboratory animal models that abnormal cortical activity is likely associated with tinnitus.[8]

As it is beyond the scope of this article to discuss the findings from the numerous studies that have used laboratory animal models for tinnitus research, interested readers are encouraged to refer to comprehensive review articles on the topic.[9–11] In the following sections, I will highlight the results from some recent experiments that my colleagues and I conducted while at the Center for Hearing and Deafness at the University at Buffalo, in which we used rat models to study noise- and drug-induced tinnitus.

In a series of experiments led by Daniel Stolzberg,[12–14] we investigated the relationship between drug-induced tinnitus and changes in neural activity in the auditory cortex. To induce tinnitus, we treated rats with a high dose of salicylate, which is a component of Aspirin that is known to induce temporary tinnitus in both rats and humans. Once anesthetized, we inserted microelectrodes into the rat's auditory cortex, and recorded the activity of neurons before and after salicylate treatment. In our first study,[12] we found that salicylate caused the majority of neurons in the auditory cortex to become particularly sensitive to sound frequencies that matched the previously established tinnitus pitch in rats; findings which suggest that abnormal cortical activity underlies salicylate-induced tinnitus. In a follow-up study,[13] we recorded the activity of neurons located at different depths of the auditory cortex, and found that the abnormal cortical activity observed during salicylate-induced tinnitus was not simply inherited from subcortical brain regions, but was also generated within the cortex itself via altered processing in its upper layers. This finding further supported our suggestion that abnormal auditory cortex activity contributes to salicylate-induced tinnitus.

Unlike salicylate, which reliably induces tinnitus in rats in a dose-dependent manner, in order to study the neural basis of noise-induced tinnitus it is very important to screen each animal behaviourally because not all noise-exposed animals develop tinnitus. To date, the most commonly used behavioural tool to screen animals for noise-induced tinnitus has been the gap-startle paradigm, which was developed by Turner and colleagues.[15] In contrast to the previously-described behavioural tests which involved training animals prior to inducing tinnitus, the gap-startle paradigm does not require overt training, as it is based on an animal's ability to detect a silent gap in a background sound as well its reflexive "flinching" response to a loud sound (i.e., its acoustic startle reflex). A key feature of the gap-startle paradigm is the well-established finding that if an animal is able to detect a brief silent gap in a background noise prior to the loud startle stimulus, its acoustic startle reflex will be suppressed (i.e., it "flinches" less in response to the loud sound). Supporters of the gap-startle paradigm suggest that if the animal's tinnitus pitch is qualitatively similar to the background sound, then it should be unable to detect the silent gap, and consequently, its acoustic startle reflex will not be suppressed. It should be noted, however, that this notion of tinnitus "filling in" the silent gap has been challenged recently by a study that used the gap-startle paradigm on humans with tinnitus.[16] Moreover, in a study on rats that was co-led by Edward Lobarinas and Sarah Hayes,[17] we identified an additional caveat of the gap-startle paradigm: it is not resilient to the hearing loss that often accompanies noise exposure, and as a consequence, animals with only hearing loss can be falsely-screened as having tinnitus. Clearly, a failure to accurately screen animals for the presence/absence of tinnitus represents a significant concern for researchers who intend to subsequently investigate its neural basis.

While it is certainly more challenging to have a laboratory animal behaviourally report whether or not it is experiencing tinnitus than it is to simply ask a person, there are some distinct benefits of using laboratory animal models for tinnitus research. For example, laboratory animal models allow researchers to (1) directly record neural activity from various brain regions using microelectrodes (as described above), (2) precisely control how tinnitus is induced, and (3) evaluate the efficacy of novel treatments for tinnitus. Furthermore, my colleagues and I contend that an effective way to investigate the neural basis of noise-induced tinnitus involves a longitudinal study design in which a given subject's brain activity is recorded both before and after traumatic noise exposure; an experimental approach that is unacceptable for human studies. To that end, Daniel Stolzberg recently led the development of the first laboratory animal model that would not only allow for us to monitor a rat's cortical activity before and after tinnitus induction, but would also permit us to record this cortical activity at the very moment when tinnitus was reported behaviourally.

As described in our recent publication.[14] we validated the efficacy of our novel rat model by exposing them to a high dose of salicylate. Because subjects with tinnitus no longer perceive “quiet,” we designed the behavioural paradigm so that a rat would screen positive for tinnitus if it mistakenly reported that it was “hearing” a steady noise during an actual quiet period. Briefly, rats were trained to self-initiate a trial by poking their nose into a center port located on the front wall of a behavioural chamber, and wait ~6 seconds for a light to provide a “go” command. During this “holding time,” the rat attended to the sound being presented from an overhead speaker, and then made the corresponding behavioral choice once the light illuminated. Rats were trained to go to a left-side feeder trough for various steady noises (which sounded like continuous hissing), and the right-side feeder for both quiet (speaker off) and amplitude-modulated noise (which sounded like a pulsing effect). As predicted, after salicylate treatment, the rats correctly identified the steady noises (left-side feeder) and amplitude-modulated noises (right-side feeder), which confirmed that they could still accurately process auditory stimuli; however, they mistakenly went to the left-side feeder during the quiet trials, which indicated that they perceived a steady phantom sound (i.e., tinnitus). Using microelectrodes that were chronically implanted into the auditory cortex, we recorded the neural activity during the “holding time” of the quiet trials. Importantly, during salicylate-induced tinnitus, we observed complex changes in the pattern of spontaneous cortical activity in the quiet trials that largely paralleled that which has been reported in non-invasive studies on humans with tinnitus.[4,6,18] Consequently, we now have a strong rationale for using our rat model to investigate the molecular mechanisms that underlie this abnormal neural activity associated with tinnitus.

Motivated by our recent findings, my colleagues and I are preparing to use our novel behavioural paradigm to track the changes in cortical activity associated with the onset and persistence of noise-induced tinnitus. Moreover, we will extend our rat model to investigate whether there are particular risk factors that can increase one’s susceptibility to developing chronic tinnitus after exposure to loud noise. Ultimately, given the expanding international community of scientists and clinicians devoted to uncovering the neural basis of tinnitus, I anticipate that laboratory animal models will continue to serve an important role in future tinnitus research.

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dB, dBA, SPL, HL, Leq, Lx, WHAT ELSE?

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About the Author

Alberto Behar is a professional engineer and certified industrial hygienist. He graduated from the University of Buenos Aires, Argentina and holds a Diploma in Acoustics from the Imperial College, London, UK. Since 1992 he is the president of Noise Control dealing with occupational and environmental noise and vibrations. He is an adjunct assistant professor at the University of Toronto and research assistant at the Ryerson University

He has been active for over 40 years in the field of hearing conservation and noise and vibration measurement, assessment and control in Argentina and in Canada both as a researcher and consultant. He has published over 50 peer-reviewed papers in international journals and is the author of two books.

Alberto is a chairman and member of several CSA and ANSI and ISO standard committees and working groups. In recognition of his activities at the CSA, he was just awarded the Award of Merit at that prestigious institution. A former president of OHAO he is active in delivering noise and vibration presentations at conferences as well as in teaching courses at different levels.

As a matter of fact, he just came back from delivering a seminar on Hearing Conservation at the University of Tres de Febrero in Buenos Aires, Argentina.

Why noise is so complicated, that needs so many units? Do we really need them?

Well, have a look at your smart phone. How many apps do you have? (If you don't have one, ask your grandson, who most probably has one, or even two). Do you really need all of them? Same thing here: as with the sound units, if you use them, you really need them.

Let's have a little walk to find out that they are not that terrible as they look like. Let's start with the good old **dB**, or decibel. Funny enough, it is not a unit per se, but a logarithmic relation of a value to another one chosen as a base.

The formula is simple enough:

$$dB = 10 \log a/A$$

where *a* is the value and *A* is the base. And the result is expressed as "**level**." For example, let's measure divorces in dB, can we? Yes, of course. Only, we have to choose a number as a base. For instance, if we have 20 divorces for each 100 marriages, then the divorce level in dB will be:

$$= 10 \log 20/100 = -14 \text{ dB}.$$

Simple, right?

In the case of noise, we use a slightly modified formula:

$$20 \log(p/p_0)$$

where p is the sound pressure that we want to measure in dB and p_0 is the reference pressure chosen to be 2*10–4. (Some of you may remember that the

Table 1. Allowable Noise Exposure

Duration (hr)	Sound level CSA/NIOSH dBA	Sound level OSHA dBA
16	82	85
8	85	90
4	88	95
2	91	100
1	94	105
0.5	97	110

reference pressure is the minimum pressure that we can perceive as "noise".)

So, there we are. Now, to make things simpler, as mentioned above, we never use the term "sound pressure," but **Sound Pressure Level**, in **dB**.

And what about this dBA business? Well, since we don't perceive the same level at different frequencies as having the same loudness, we adjust the level according to the frequency. No fear: this is done automatically in the measuring instrument and the result is read as dBA. Another advantage of dBA is that it is proportional also to the risk of hearing loss of the exposed person, as well as to the sensation of annoyance.

So, dealing with noise (regarding risk and annoyance) we don't use sound pressure, nor sound pressure level, but **sound level in dBA.**

HL? Finally something well known: the **Hearing Level** that appears on the Y axis in our audiometry. Another one in dB, *but* related to the hearing threshold level and not to the threshold of hearing. Let's explain it: the threshold of hearing changes with the frequency, as explained above. The hearing threshold is the difference in dB between the actual threshold level of our patient and the nominal threshold level of the average listener. And that is the level that appears in our audiometer too.

So much about **sound levels**.

Let see now something about **noise exposure levels** (also known as **noise exposure**). We all know that occupational hearing loss is *the* result of long exposures to loud noise. We have also familiar with the allowable exposure shown as Table 1 further in the text.

Here the allowable duration of exposure at different sound levels is shown. The sound levels correspond to two different guideline/standard, known also as 3 dB (CSA/ISO/NIOSH) and 5 dB (OSHA) exchange rates. It shows clearly that the CSA/NIOSH guideline is more conservative, since it allows for 85 dBA for 8hs, while OSHA allows for 90 for the same time period. Also, the exposure duration is reduced by half, every time the sound level increases by 3 dBA, while OSHA allows for an increase of 5 dBA for the same time duration.

Now, there is a concept that combines the duration and the sound level. It is called noise exposure level (or simply noise exposure) and it is also measured in dBA. It is expressed as Leq (equivalent noise levels). Fortunately, it is measured with an instrument called dosimeter. The beauty of it is that there is no need for calculation: the worker has to wear it during the entire shift. At the end it provides the reading of the noise exposure. So, if this reading is below 85 dBA, then the worker is not at risk. On the contrary, if the level exceeds 85 dBA, then, there is a risk and something has to be done to reduce his noise exposure! It can be engineering noise control (THE BEST), reduction of the exposure duration or, simply, use of hearing protectors.

Congratulations for being heroic and for managing to get to the end of this article. Obviously it is not an easy read, but it is necessary to help navigate through the several concepts related to the noise and the risk of hearing loss!

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Accuracy of Smartphone Sound Level Meter Applications

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ABSTRACT
Noise-induced hearing loss, resulting from over-exposure to loud sounds, is becoming increasingly prevalent among youth. Regulations established by the federal government recommend a maximum sound exposure level of 87 dBA for 8 hours, with an exchange rate of 3 dBA. Although sound level meters and dosimeters are accurate at measuring noise levels, they are expensive and inaccessible to the average individual. Smartphones, on the other hand, are widely available to the average consumer and contain various downloadable applications. Several sound level meter "'apps'" may be a more cost-effective solution to determining noise levels in various environments. This study examined the accuracy of three different free sound level meter 'apps' apps on iPhone® and Android® smartphones. Measurements were taken of pink noise from the QuickSIN3 test at 85 dB HL and 95 dB HL and compared to a gold standard, type I sound level meter. Results indicated that the Android apps were inaccurate at determining noise levels and under reported the true level of the noise. The iPhone® apps performed well at the low intensity level. However, at 95 dB HL, measurements on all three apps were inaccurate because the values saturated after a maximum level. Therefore, while sound level meter applications may be used on smartphones such as iPhones® and Androids® to help evaluate the noise conditions of an environment, they may have limitations in their accuracy. Audiologists are advised to validate sound level meter applications against an independent source across input levels prior to use.

INTRODUCTION
The prevalence of noise-induced hearing loss (NIHL) is currently on the rise amongst youth. According to one study, one in five teenagers aged 12 to 19 years have some degree of hearing loss, representing a 30% increase over the past 10 years and is at least partially attributable to noise damage.[1–3] Knowledge regarding safe listening levels and durations, as well as the tools to assess a given noisy environment and appropriate education, allow listeners to take appropriate action to protect their hearing.[4] Such action may include reducing the sound level, moving away from the sound source, limiting time in noisy environments, and using hearing protection.[5] Canadian Federal regulations recommend a maximum permitted sound exposure level for 8

hours of 87dBA with an exchange rate of 3 dBA.[2] Levels above this limit expose the listener to risk of acquiring a permanent NIHL.

Reliable sound level estimates are essential to identify potentially hazardous listening situations. Devices such as dosimeters and sound level meters (SLMs) can be used to make such measurements, but are often extremely expensive –- ranging from hundreds to thousands of dollars –- making them impractical for the general population. A more accessible and cost-friendly option may be to use an SLM app for smartphones. Rapid technological advances in mobile devices have allowed for more computational power to support more advanced uses and new ways of interacting with technological artifacts have been enabled.

In 2010, Statistics Canada conducted a residential phone survey that reported that 78% of Canadian households have had access to a cell phone as of 2010, 41% of which are smartphones.[6] SLM apps are a potential cost-effective and appropriate choice to identify and monitor dangerous noise levels in various environments, especially given the widespread accessibility and popularity of smartphones. However, the accuracy of smartphone SLM apps is critical for making appropriate sound level approximations.

While there are several articles in the grey literature evaluating the accuracy of smartphone SLMs,[7,8] there is a marked lack of peer- reviewed research on this matter. One study examining five different SLM apps for the iPhone® in a controlled setting using narrowband noise discovered that while some apps consistently overestimate sound levels, others underestimate it. Accuracy also varied as a function of frequency and level. It was concluded that further investigation should take place to confidently report accuracy of SLM apps in real-world settings.[9] Another study compared five different iPhone SLM apps to a Type type II SLM in five different environments. It also concluded that some SLM apps are more accurate than others, but the environment in which the measurement was taken also proved to be a factor in accuracy.[10]

The present study attempts to determine if the accuracy of three different SLM apps on several iPhone® and Android® phones is similar to that of a Type type II SLM.

Table 1. Description of SLM applications were chosen based on the most up-to-date app on the iTunes App Store and Google Play Store, respectively, as of March 4, 2013.

iPhone® App	Android® App
Decibel 10th by SkyPaw Co. Ltd	Sound Meter V2.1 by Borce Trajkovski
Decibel Meter® FREE by Byounghun Jang	Noise Meter 2.1 by JINASYS
dB Volume by DSP Mobile	Sound Meter version 1.4.10 by Smart Tools co.

Table 2. Phones included in this study.

Android® Models	Number of Phones	iPhone® Models	Number of Phones
Samsung Galaxy Ace	3	iPhone 4	5
Samsung Galaxy	1	iPhone 4s	3
Samsung Galaxy Note 1	1	iPhone 5	1
Samsung Galaxy Note 2	1		
Nexus 4	3		
LG Optimus One	1		
HTC Touch 1	1		
HTC Desire	1		

METHOD

The three most up-to-date free SLM applications were each chosen from the iTunes App Store and Google Play Store, as of March 4, 2013. For the purposes of this study only free SLM apps were selected. The chosen apps and their associated names can be seen in Table 1.

The sound levels were recorded in a double-walled 10 × 12 foot sound booth. A recently re-certified and calibrated Larson-Davis 824 Type type I SLM was used as a gold standard reference The SLM microphone was placed on a stand at the soundfield calibration point at 170 cm from the speaker. Phones were held by hand at the same location with their microphones oriented towards the speaker. One tester was outside of the sound booth and manipulated the audiometer while two testers remained in the sound booth to position the devices and record the sound level values. If an app's sound level was fluctuating, its mean level was taken as the measurement. The stimulus used was pink noise from the QuickSIN3 presented using a GSI 61 audiometer via R300 external power amplifier and Mission M32I speaker at both 85 dB HL and 95 dB HL. High level stimuli were chosen to evaluate app performance at potentially dangerous noise levels and to investigate potential microphone saturation effects. Applications on 9 iPhone® and 12 Android® phones were measured (Table 2). The phones were of varying make, model and age. Protective cases remained on, if applicable. The

Table 3. iPhone – % of measurements that were within +/- 3dB of a type I SLM.

% 3dB Tolerance:	Level	Decibel 10th	Decibel Meter	dB Volume	dB Volume*
	85 dB HL	100%**	100%**	67%	11%
	95 dB HL	0%**	0%**	22%	11%

* Apps that had settings modified from default to dBA measurements.
** Denotes groups that had significantly different performance from the type I SLM on average according to unpaired post hoc *T*-tests with a Bonferroni correction.

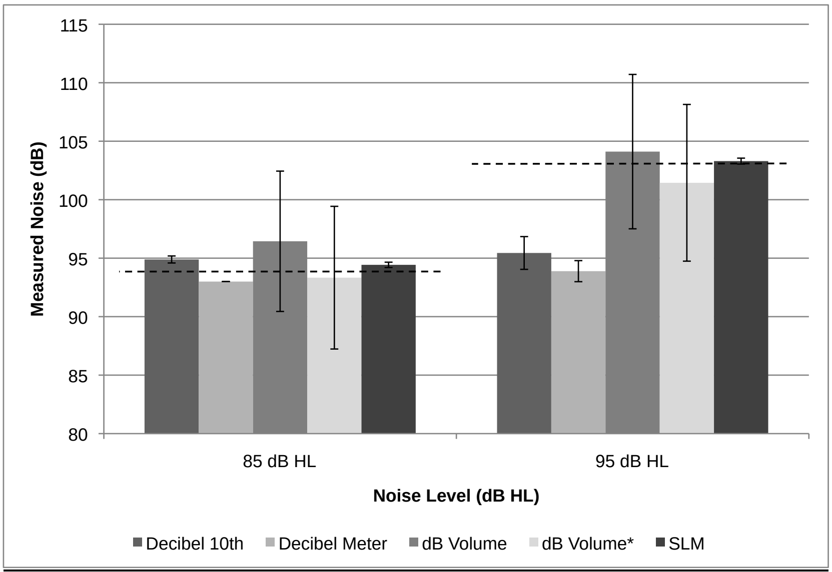

Figure 1. iPhone - Measured Noised dB (y-axis) by different noise levels (x-axis) with error bars on graphs show standard deviation with different applications.

SLM settings were changed to dBA and measurements on the smartphones were left at default or changed to dBA to match the SLM when possible.

RESULTS

Statistical analyses used to test the accuracy of apps consisted of One Way ANOVAs with post hoc unpaired *T*-tests with a Bonferroni correction. In order to compare to a relatively inexpensive type II SLM, results were also analyzed in terms of +/- 3 dB tolerances. The +/- 3 dB tolerance was used to include the tolerance associated with the Type type I SLM used as the gold standard in this study (+/- 1dB), added to the tolerance associated with a type II SLM (+/- 2dB) are additive. As shown in Table 3. The * denotes apps that had settings modified from default to dBA measurements.. While ** denotes groups that had significantly different performance from the type I SLM on average according to unpaired post hoc T-Tests with a Bonferroni correction.

IPHONE® RESULTS

The One Way Repeated Measures ANOVA revealed a significant effect of sound level, measurement device, and an interaction. Results can be seen in Figure 1. Results for the iPhone® revealed that at 85 dB HL, dB Volume was not significantly different from the SLM, while *Decibel 10th* marginally overestimated the sound level, and *Decibel Meter* was significantly lower than the SLM. Perhaps more importantly, all of the readings from *Decibel 10th* and *Decibel Meter* were within +/- 3 dB tolerances. The majority (67%) of the readings for *dB Volume* were within +/- 3dB tolerances. At 95 dB HL, *dB Volume* was again not significantly different from the SLM. *Decibel 10th* and *Decibel Meter* were significantly lower than the SLM. At this level, looking at +/- 3dB tolerances, *Decibel 10th* and *Decibel Meter* never measured within the required range, and *dB Volume* was only within tolerance 22% of the time. In addition, the *dB Volume** app was the only iPhone® application in which the settings could be modified. When the settings were changed from the default to dBA, this reduced the proportion of measures within tolerance to 11% of samples across levels, but was not significantly different on average (Table 3).

Overall, multiple iPhone® apps were as good as a type II SLM at the lower 85 dB HL level. Those that were not accurate both over and under estimated the true level. In contrast, at 95 dB HL only one app was ever within type II SLM specifications and even then in only 22% of phones tested. Looking at app performance at both levels, only *dB Volume* had acceptable performance on average across both levels but also varied across individual phones on which it was functioning.

ANDROID® RESULTS

Results can be seen in Figure 2. Compared to the relative reliability of the iPhone® 'apps', the Android® results indicate that at the 85 dB HL level, *Sound Meter (ST), Sound Meter (BT),* and *Noise Meter* were all significantly lower than the SLM. Only *Sound Meter (BT)* was ever

Table 4. Android®– % of measurements that were within +/- 3dB of a type I SLM.

% 3dB Tolerance:	Level	Sound Meter (ST)	Sound Meter (BT)	Noise Meter	Noise Meter*
	85 dB HL	0%**	33%**	0%**	0%**
	95 dB HL	0%**	0%**	0%**	0%**

* Apps that had settings modified from default to dBA measurements.
** Denotes groups that had significantly different performance from the type I SLM on average according to unpaired post hoc *T*-tests with a Bonferroni correction.

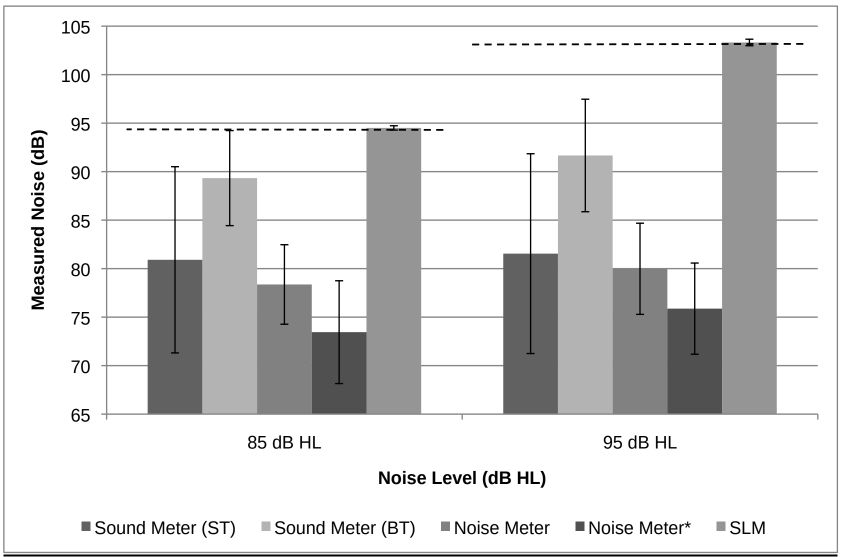

Figure 2. Android - Measured Noised dB (y-axis) by different noise levels (x-axis) with error bars on graphs show standard deviation with different applications.

within tolerance and even then was only within tolerance in a third of test cases. At the 95 dB HL level, *Sound Meter (ST)*, *Sound Meter (BT)*, and *Noise Meter* were, again, all significantly lower than the SLM and none of the 'apps' were ever within +/- 3dB tolerances at this level. When *Noise Meter** was modified to the dBA settings, this made its sound estimate worse at both levels. Therefore, in nearly all cases, Android® sound meter performance was unacceptable (Table 4). Unlike with some iPhone® apps that overestimated as well as underestimated sound level, the Android apps tested in this study nearly always underreported the true sound level. In addition, Android® apps yielded less consistent results between phones. Variability with the Android app results may be a result of differing hardware on the Android® platform versus the iPhone® platform, which produced more consistent results.

DISCUSSION

The accuracy of six different SLM apps on various Android® and iPhone® models was tested and proved to be variable in performance. Overall, the three Android® apps were inaccurate at estimating noise levels at both intensity levels and nearly always under reported the true sound level. The iPhone® apps performed well at the low intensity level; however, at 95 dB HL, measurements were generally inaccurate. When considering using such an application to evaluate safe noise levels, underreporting the level is clearly much more of a concern as higher levels put the user at greater risk. Overall, the *dB Volume* app on the iPhone® was observed to be the most accurate and could potentially be used by the average consumer to estimate noise levels in loud environments.

Limitations of the current study include varied smartphone hardware, especially among Android devices. This may account for the increased variability in measurements from Android apps. In this study, we only used SLM apps that we were not charged a fee for (i.e., they were free). It is unknown if the accuracy of these free apps is comparable to that of the apps available for purchase, which may be of higher quality. What is clear, is that it would be beneficial for audiologists to evaluate the accuracy of any SLM app they wish to use in their own clinical environment prior to use and recommendations to their clients.

Future research is needed to investigate why the accuracy of most apps decreased as the stimulus level increased. It is possible that this occurred due to microphone saturation or compression algorithms. Measuring responses at an additional lower level would be beneficial, as these effects may have already been present at 85 dB HL. It is also unknown why changing the settings from default to dBA –– to better approximate the type I SLM –– actually made the sound readings less accurate.

NIHL can happen to anyone. If individuals were more aware of the harm of certain environments, they may be inclined to take the necessary measures to prevent it from occurring. Easily attainable and affordable methods of educating the public, such as the dB Volume app on the iPhone®, may help decrease the prevalence of NIHL.

ACKNOWLEDGEMENTS

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Estimating Noise Exposure Under Headsets

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About the Author
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More and more people are wearing headsets at work. They are found in retail stores, drive through restaurants and call centres as well as more traditional occupations like pilot and radio operator.

CSA Z107.56 is a well known Canadian Standard used to measure the noise exposure of employees under many different situations. However it does not yet provide information about measuring the noise exposure of people who are wearing headsets. A new appendix has been written to address this shortcoming. The appendix is based in part on ISO and Australian standards which use one of two methods. The microphone in real ear method involves a small microphone placed inside the headset. The Mannequin method involves measurement of the signal from the headset using a either a specially constructed mannequin or an artificial ear.

Because these measurements require equipment and expertise beyond the normal range of industrial hygienists and safety personnel, there was a concern that reliance on these measurements might severely limit the workplaces where the employee noise exposure from headsets could be measured. This would have been counter-productive. In many common cases, such as call centers, retail stores, fast food, etc. the sound level from the headset is adjusted to allow it to be heard over the existing reverberant background noise. In many such cases, there was the possibility that the exposure measurements could end up costing almost as much as it would cost to reduce the background sound level by controlling reverberation, use of barriers or headsets inside conventional muff type hearing protectors.

The calculation method proposed in the new draft Appendix of Z107.56 provides a simpler approach which can be carried out by an industrial hygienist or safety officer using the same equipment used to measure noise exposure. While recognizing the lower accuracy inherent in such an assessment, it can provide a first step in assessing and resolving these situations.

Measurements have shown that in many cases the sound level produced by a headset is adjusted by the user to be about 15 dB above the existing background noise under the headset. This simple fact provides the basis for the method. The measurement procedures are the same as used for employees without headsets. The sound level under the headset is calculated by subtracting the published headset attenuation from the sound level measured in the area using standard techniques. The sound level from the headphone signal is assumed to be 15 dB higher and the noise exposure is calculated based on the times the headphone signal is on and off during a typical workday.

For a regulated limit of 85 dBA, this would mean that the combination of the background noise coming through the headset and the expected noise produced by the headset signal (itself 15 dB above the background noise inside the headset) should be no louder than 85 dBA. Most headsets provide little or no protection against external noise. Accordingly, the noise reduction of the headset is assumed to be zero unless the manufacturer can provide user fit octave band insertion loss data taken according to ANSI S12.6. The calculation must also account for the time the headset signal is on.

An example of a simple calculation without and with headset attenuation is given below in Tables 1 and 2. The calculations shown here are simplified. The actual noise reduction of the ambient

Table 1. Example exposure calculation without headset attenuation (0 dB)

	SL, dBA	Duration, Hr
Room Ambient	70	8
NR of headphone (set to 0 if no user fit data available)	0	
Ambient noise level under headset	70	
Headphone sound level when on (Leq)	85	
Hours headphone signal is on		1
Hours headphone signal is off		7
$L_{ex,8h}$ from ambient noise	**70**	**8**
$L_{ex,8h}$ from headphone signal	**76**	**8**
Total $L_{ex,8h}$	**77**	8

Table 2. Example exposure calculation with headset attenuation (20 dB)

	SL, dBA	Duration, Hr
Room ambient	80	8
NR of headphone (set to 0 if no user fit data available)	20	
Ambient noise level under headset	60	
Headphone sound level when on (Leq)	75	
Hours headphone signal is on		1
Hours headphone signal is off		7
$L_{ex,8h}$ from ambient noise	**60**	**8**
$L_{ex,8h}$ from headphone signal	**66**	**8**
Total $L_{ex,8h}$	**67**	**8**

by the headset would have to be calculated in either octave or 1/3 octave bands. This calculation is not shown here since it is straightforward to do and adds little to the discussion.

Note that unless the use of the headset is extremely intermittent, the L_{ex} from the ambient inside the headset is much lower than the sound from the headset. If the headset is used more than 1 hour per day, the ambient has less than 1 dB effect on the result. In such cases the sound level under the headset can be calculated by simply adding 15 dB to the $L_{ex,8h}$ measured outside the headset (corrected for headset signal duration), reduced by the NR of the headset (which is zero for most headsets).

Another way to look at it is that unless the headset can be shown through subject fit data to reduce the sound level by more than 15 dB, using the headset will increase the noise exposure of the employee above the $L_{ex,8h}$ measured outside the headset unless the headphone signal is used very rarely. For example, a normal headphone in use all day in an ambient of 80 dBA would produce a noise exposure of 95 dBA. Reducing the headset use to 2 hours a day would still give an exposure of 90 dBA. Only if the headset gave at least a 20 dB reduction (typical of a reasonably good muff) would it start to give as little as 5 dB of protection to someone using the headset continually.

This appendix gives a new capability for assessing the noise exposure of employees who could not be assessed before. It also points up the potential for headsets to be a significant source of noise exposure to those who wear them in even moderately noisy environments and the effect even a small amount of headset use can have on the protection provided even by very good muffs. Industrial hygienists are going to have to take a good look at any situation where employees use muffs for both protection and communication. In many such cases they may not be getting the protection they need.

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A Veteran with a New Look

CSA Z107.56–13: Measurement of Noise Exposure

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Alberto Behar is a professional engineer and certified industrial hygienist. He graduated from the University of Buenos Aires, Argentina and holds a Diploma in Acoustics from the Imperial College, London, UK. Since 1992 he is the president of Noise Control dealing with occupational and environmental noise and vibrations. He is an adjunct assistant professor at the University of Toronto and research assistant at the Ryerson University

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Alberto is a chairman and member of several CSA and ANSI and ISO standard committees and working groups. In recognition of his activities at the CSA, he was just awarded the Award of Merit at that prestigious institution. A former president of OHAO he is active in delivering noise and vibration presentations at conferences as well as in teaching courses at different levels.

As a matter of fact, he just came back from delivering a seminar on Hearing Conservation at the University of Tres de Febrero in Buenos Aires, Argentina.

Dave Shanahan is OHS Standards project manager. He has been a health and safety manager for 20 years with various industrial, mining, chemical, and forestry companies. During those years, he participated in a number of standards development committees and became familiar with the value of quality OHS standards.
He joined Canadian Standards Association 15 years ago to lead the process of making CSA's OHS standards more applicable to the workplace and useful to workers, safety committees, and OHS professionals.

As the OHS Standards Project Manager he facilitates 18 Technical Committees developing many of CSA's more than 150 occupational health and safety standards and guidelines.

The new edition of CSA's Z107.56 Standard has just been published. Initially released in its English-language version, Z107.56 will be available later this year in a French-language version. While this 4th edition of the Standard is not entirely new, it is much more than a simple technical update. In fact, it has been greatly revised with the addition of entirely new material on consideration for sound sources close to the ear (e.g., communication headsets) and methods for calculating the combined effects of both near-ear sources and other noise sources in the surrounding environment. There is also a discussion of the effect of radios and music players on noise exposure.

It has to be said that the standard is not completely new: CSA Z107.56 has come a long way since it was first published in 1986. Over the intervening years, it has become very popular with the occupational hygiene community and is reference by many jurisdictions in Canada. Subsequent updates were issued in 1994 and 2006. The present edition changes the name of the Standard that used to be "Procedures for the measurement of occupational noise exposure." Obviously, the concept of noise exposure is independent of the nature of the noise, whether it is occupational, recreational or military…

ISO and ANSI have also produced standards that deal with this subject.[1] However, the CSA document predates them and takes a more practical approach to the mechanics of performing noise exposure surveys. As indicated above, the new edition also includes procedures for the measurement of exposures from a wide range of sources – far-field sources, at-ear sources, ambient environmental noise, point (localized) sources, and diffuse sources – and then combining these measurements to estimate the composite exposure for an individual over time.

NOISE EXPOSURE LEVEL / WHAT'S THAT?

Let's explain this concept and see why it is so important.

We all know that hearing loss is the consequence of long exposures to high noise levels. We also know that noise levels that may damage our hearing exceed 85 dBA.[2] Regarding the duration of sounds, with the exception of high level impulses (usually found in the military), we are talking of exposures repeated year after year. Noise exposure is a concept that combines both: level and duration in a single number, expressed in dBA. It is the energy average of the sound levels the person is exposed to during the exposure period.

We will spare our readers the formula and will simply state that noise exposure level is usually measured using an instrument called a noise dosimeter. It is worn by the person whose noise exposure level is measured during the entire shift or period of exposure. At the end, the value is read directly on the instrument or on a remote reader.

Finally, the assessment of the risk of hearing loss is done by comparing the measured noise exposure level against limits set by National, Provincial or professional guidelines or limits. The results can also be compared with ISO 1999 to determine the statistical likelihood of hearing loss.[3]

SO, WHAT'S IN THE STANDARD?

As in any other similar document, Z107.56 begins by stating its scope and intended application. Following this, there are sections listing the referenced documents and definitions of terms used in the Standard. Then the main body contains sections describing the instruments used for the measurement of the exposure – including sound level meters, integrating sound level meters, and noise dosimeters – and a section on noise measurement procedures.

The Standard strongly recommends the use of dosimeters or integrating sound level meters in measuring exposures for individual workers. Requirements and advice for measurement procedures is quite extensive – going into some detail on the methods available for various applications. Having the proper instrument is half of the story: unless proper procedures are followed, results can be totally wrong or unreliable.

For sources far from the ear the procedures are essentially unchanged, so results taken according to the old standard continue to apply and those using the standard now will not have a lot of new learning unless they have to deal with sound sources close to the ear.

MEASUREMENT OF NOISE EXPOSURE FROM SOUND SOURCES CLOSE TO THE EAR

This is completely new section that is dealing basically with headsets used for communication purposes. Those are devices, increasingly popular, that are found at places such as call centers, fast food take out counters, airport control towers, etc. Also, communication headsets are used inside noisy industrial or mining environments, trucks and the military.

The existing measuring techniques for headsets are quite sophisticated and require specialized instrumentation and techniques. To simplify the procedure, the Standard includes a not so precise way of calculating the noise exposure, based simply on the measurement of the background noise at the location where the communications take place.

ANNEXES

The Standard includes five annex sections. Some of them refer to best practice; one such is Annex A, "Guidelines on worker involvement in a noise exposure measurement". Others, such as Annex B "Noise exposure of groups", deal with situation of large number of employees performing the same task or working in the same noise environment.

In Summary

The new Standard will serve as a nationally recognized means for assessing exposure to hazardous noise levels, fill a gap in the literature on the subject (especially regarding exposure from communication headsets), and provide a basis for managing workplace noise (hearing loss prevention).

FOOTNOTES

1. The following standards deal with the subject:
   ISO 9612:2009: Acoustics -- Determination of occupational noise exposure -- Engineering method
   ISO 1999:1990: Acoustics -- Determination of occupational noise exposure and estimation of noise-induced hearing impairment
   ANSI S3.44-1996 (R 2006):Determination of Occupational Noise Exposure and Estimation of Noise-induced Hearing Impairment (with Erratum)
2. The exact value can be discussed, but there is definitely a level below which most people's hearing won't be affected. This is somewhere between 70 and 85 dBA.
3. ISO 1999 Acoustics -- Estimation of noise-induced hearing.

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